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Characterization of the Bioenergy Potential of Corncob and Rice Husk mixtures in Biochar Briquettes

Asrori Asrori[1*], Mirza Fathus Syifa Alfarisyi[2], Ach. Muhib zainuri[3], Eko Naryono[4]

[1,2,3]*Departemen of Mechanical Engineering, State Polytechnic of Malang, Indonesia*
[4]*Department of Chemical Engineering, State Polytechnic of Malang, Indonesia*

Aauthor Email: asrori@polinema.ac.id, achmad.muhib@polinema.ac.id, eko.naryono@polinema.ac.id

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ABSTRACT

Briquettes are a form of solid fuel that is produced using waste from the agricultural, industrial and household sectors. For example, briquettes can be produced from biomass waste such as rice straw and corn cobs, which are potential resources that can be utilized to produce bioenergy in the form of briquettes. This study aims to develop and test the characteristics of biomass briquettes in order to evaluate the quality of the biochar briquettes and the calorific value they produce. The method used in this study was experimental, in which the adhesive and the composition of the mixed ingredients were varied as independent variables to affect the quality of the briquettes, while the moisture content, ash content, burning rate,put birds, calorific value is used as the dependent variable. In this study, the results obtained for moisture content≤ 5%, volatile matter ≤ 10%, calorific value≤ 6.553 cal/g, and a burning rate of 0.17 gram/minute which is expected according to the Indonesian National Standard (SNI) 01 6235 2000, namely the moisture content≤ 8%, volatille matter ≤ 10%, calorific value≤ 5,000 cal/g. The results of this study indicate that the biomass briquettes can meet the established quality standards, with appropriate moisture, ash and volatile matter content. In addition, the resulting calorific value also reaches the desired figure, indicating the potential of biomass briquettes as an efficient alternative fuel. The combustion rates found in this study also indicate that the biomass briquettes have characteristics that allow stable and effective combustion. Thus, this research succeeded in developing and testing the characteristics of biomass briquettes as an alternative fuel. The results of this study can contribute to the development of renewable energy sources and efficient use of biomass waste, as well as promote efforts to mitigate the negative impacts of the conventional energy sector on the environment.

Keywords: *Biomass, Rice Husk, Corn Cob, Briquette Quality*

1. INTRODUCTION

Charcoal briquettes are solid fuel that does not produce smoke, so they are safe to use without harming the health of the user. Briquetting is done to produce a shape that suits the needs of a particular use. Charcoal briquettes are made from various biological materials or biomass such as wood, twigs, leaves, grass, straw and other agricultural waste [1–6]. Through the processing process, this biomass is converted into charcoal briquettes, one of which is biocharcoal briquettes. By using charcoal briquettes, we can reduce the use of fossil fuels and switch to renewable energy sources [7–11]. Using charcoal briquettes also has a lower environmental impact because it reduces smoke emissions and other pollutants. Therefore, charcoal briquettes are an environmentally friendly alternative and have the potential to be developed as a sustainable energy source [12–16].

Corn cobs are waste from plants whose use is still minimal. The amount of corn cob waste will increase continuously if farmers can handle the waste by burning it. Corn cobs have a high fiber content, namely 33%, with a cellulose content of around 44.9% and a cellulose content of 33.3% which is then made into charcoal briquettes as alternative energy [17–20]. Not only corn cobs, rice production in large quantities can be turned into rice husks in the form of agricultural waste which is used as a planting medium and burned as trash. Rice husks can be used as biomass material from a potential carbon source which can be used as fuel which can also be used as alternative energy [21–23].

In Indonesia, there are many alternative renewable sources, including those originating from biomass or organic waste. Biomass that has quite large potential is corn cobs to increase the economic value of biomass by processing it into charcoal briquettes. Charcoal briquettes are a fuel that contains high carbon and calories and can burn for a long time as energy consumption. Briquettes need to be considered among households to prevent air pollution caused by combustion smoke [24, 25].

The best characteristics of corncob organic waste briquettes are using a variety of tapioca flour and wheat flour adhesives with respective mixture composition percentages of 5%, 10% and 15% [26]. Apart from using tapioca flour and wheat flour adhesive, you can also use starch alone with a mixture composition of 5% and 10% to get results in accordance with SNI 01-6235-2000 [27].

As economic growth develops, the industry for making charcoal briquettes from corn cobs and rice husks is still undergoing economic studies, even though the raw material and market potential are quite large. There are several obstacles in developing this small industry, namely that it often has difficulty raising sufficient funds to develop and expand production. The limited market is a challenge for developing the charcoal briquette processing industry [28].

Some of the ingredients or materials in the briquette making process include [29,30]:

- Raw Materials

Briquettes can be processed from various raw materials, such as rice husks, sawdust, corn cobs, peat and others. The main ingredient of these briquettes must be cellulose (the main structure of the cell walls of green plants). The higher the cellulose content, the better the quality of the briquettes, briquettes that contain volatile substances (volatile meters), where those that are too large make the material emit unpleasant smoke.

- Inorganic adhesives

The use of organic binders in briquettes can maintain the strength of the briquettes during the combustion process, ensuring that the integrity of the fuel is not compromised. However, inorganic binders have the disadvantage of adding ash to the fuel, which can inhibit combustion and reduce the calorific value. Examples of inorganic binders include cement, clay, and sodium silicate. On the other hand, organic binders produce relatively small amounts of ash after the briquettes burn and generally serve as effective adhesives.

- Organic adhesives

Some examples of organic binders include starch, tar, asphalt, starch, molasses, and paraffin. One example of an organic binder is molasses, which has a crude protein content of 3.1%, crude fat 0.9%, and ash 11.9%, moisture content 15-25%. Cassava starch sago is an abundant source of carbohydrates, especially in areas with active cassava plantations. As a source of carbohydrates, cassava starch sago also contains starch consisting of amylose and amylose pectin, which allows it to bind the carbons in charcoal briquettes like tapioca.

Tapioca flour made from cassava starch has good adhesive properties when exposed to heat. When the tapioca flour is burned, it will melt and form a layer that binds the fuel particles together. Apart from that, tapioca flour has a small amount of ash after burning. Thus, the use of tapioca flour in briquettes can increase the effectiveness of the binder, maintain the strength of the briquettes, and reduce ash which affects combustion and calorific value.

Mollase in briquettes can provide benefits as an effective organic binder. When briquettes are burned, the molasses will dry out and melt. During the burning process, molasses will form a sticky layer that helps unite the fuel particles in the briquettes. Apart from being an adhesive, molasses can also provide added value in terms of increasing calorific value. However, molasses adhesive has an effect in the form of increasing ash content.

In this research, we discuss the analysis of the characteristics of the composition of corn cob waste and rice husks on the quality of briquettes for biochar using tapioca flour and molasses adhesive. The aim of this research is to formulate a comparison of adhesive variations and material percentages and determine the chemical characteristics of the biobriquettes produced.

2. RESEARCH SIGNIFICANCE

Several important points in research on biocharcoal briquettes are: (1) Development of renewable energy sources: corn cob and rice husk waste is an abundant source of biomass from the agricultural sector. (2) Converting this waste into biocharcoal briquettes can increase the use of renewable energy, reduce dependence on fossil fuels, and reduce greenhouse gas emissions. (3) Agricultural waste management, where the use of agricultural waste for the production of biocharcoal briquettes can help reduce environmental pollution problems and reduce the burden of organic waste on agricultural land. (4) This research has the potential to increase the added value of agricultural waste by converting it into products that have economic value, such as biocharcoal briquettes which can be used as alternative fuel, thereby reducing the risk of an energy crisis and increasing a country's energy security.

However, there are several weaknesses that may arise from this research, including: (1) Variability in waste composition: Agricultural waste such as corn cobs and rice husks can have varying compositions depending on factors such as soil type, climate, plant varieties, and agricultural methods. This can cause difficulties in standardizing consistent production of biocharcoal briquettes. (2) Influence of the production process: the production process of biocharcoal briquettes can affect the final quality. Variability in production parameters such as temperature, pressure, and firing time can influence the physical and chemical properties of biocharcoal briquettes. (3) Characteristics of biocharcoal briquettes: The quality of biocharcoal briquettes produced from corn cob and rice husk waste can be influenced by factors such as density, mechanical strength, calorific value and gas emissions during combustion. Evaluation of the quality of biocharcoal briquettes requires careful and accurate methodology. (4) Economic and environmental aspects: Although biocharcoal briquettes can be an environmentally friendly alternative, economic aspects such as production and distribution costs, as well as the environmental impact of the production and use processes, also need to be evaluated thoroughly.

3. RESEARCH METHODS

The research was carried out in a true-experimental manner, carried out in the Lab. Chemical Engineering, Malang State Polytechnic. The independent variables in this study were variations in the type of adhesive (tapioca flour and molasses) and variations in composition between corn cob waste and rice husks. The composition of the briquette mixture is 40 grams of rice husks with 60 grams of corn cobs; 50 grams of rice husks with 50 grams of corn cobs, and 30 grams of rice husks with 70 grams of corn cobs. Where all of these mixtures use 10% adhesive material. Meanwhile, the dependent variable is the quality of the briquettes in the form of: moisture content, ash content, combustion rate, calorific value and evaporation rate of substances.

This research uses several tools and materials to make bioarang briquettes. The basic ingredients of briquettes are shown in Table 1.

Table 1. Materials for making bioarang briquettes

Material	Function
rice husks	Rice husk is a hard protective layer surrounding rice or grain. Utilizing rice husks as an alternative fuel can reduce agricultural waste. Which will then be processed into alternative fuel, processed into briquette fuel through carbonization.
Corncob	Corn cobs are a very abundant biomass. Corn cobs are a waste product from agriculture which is usually thrown away. The use of corn cobs as raw material in making biomass briquettes is an alternative material that goes through a carbonization process.
Starch	Starch comes from tubers which are made into flour and have various functions. Starch has thickening properties and is a binder in making fuel briquettes.
Molasses	Molasses is a by-product of processing sugar cane into sugar. Molasses is a thick, brown liquid that has a high viscosity so it functions as an effective binder in making biocharcoal briquettes.

Carbonization Process

The carbonization process or coking process, namely the process of burning rice husks and corn cobs in a combustion drum for 4 hours. The tool for burning rice husk and corn cob waste is a combustion drum (Figure 2). The combustion drum has 3 parts, namely the bottom which is connected to the burner, the top of the combustion drum, the side, which is useful for blowing the combustion process so that the heat produced is stable..

Figure 2. Combustion drum

Moulding process

Meanwhile, the tool used in making briquettes is a simple printer for printing rice husk and corn cob briquettes. This tool uses a hydraulic jack with a capacity of 5 tons and uses a pressing shaft mold of Ø38 mm, a shaft groove height of 5 cm, and a mold hole of Ø28 mm. The printing pressure used is 50 bar. The briquette printing tool and the results are shown in Figure 3.

Figure 3. Moulding equipment and briquette results

3.1 Briquette Quality Characteristic Parameters

Briquette quality testing parameters according to standard (SNI) No. 01-6235-2000 :

Moisture content

The ash sample in a crucible cup was dried using an oven at a temperature of 104 -110 °C for 1 hour. Next, cool in a desiccator for 15 minutes, then weigh the results obtained. Calculation of moisture content values uses the American Society For Testing and Materials (ASTM) D-3174 standard using Eq. (1):

$$\frac{m_o - m}{ms}\ x\ 100\% \quad (1)$$

Where; mo is the mass of the sample and cup before drying [g], m is the mass of the sample and cup after drying [g], ms is the initial sample mass [g].

Ash Content

The ash sample in the crucible cup was put into the furnace at a temperature of 500º for 1 hour, then at a temperature of 750º for 2 hours, then continued to combine at a temperature of 950º for 2 hours. Continue with the cooling process, in a desiccator for 15 minutes. Next, the ash weight value is obtained from the results of the analytical balance. Calculation of ash content values, using Eq. (2):

$$(\frac{ash\ weight}{sample\ weight})x\ 100\% \quad (2)$$

Burn Rate

The samples were burned to ash using a tin stove. Burning time is recorded using a stopwatch. Next, the remaining combustion ash from each sample was weighed. Calculation The burning rate is calculated based on Eq. (3).

$$\frac{Init.\ mass\ of\ briquette - Res.\ mass\ of\ briquette}{Burning\ time} \quad (3)$$

Calorific value

The calorific value test involves measuring the amount of energy or heat produced from complete combustion of a fuel or chemical substance. This test method uses an Automatic Bomb Calorimeter, which was created to limit combustion in a closed environment. During the test, a fuel sample is ignited, and the heat produced from combustion is measured and converted into a calorific value. The higher the calorific value, the greater the energy potential and ability of the fuel to produce heat when burned.

Calorific value tests are important in evaluating fuel quality and performance and can be used in research and development of new fuels. By using an Automatic Bomb Calorimeter, testing can be carried out in a controlled manner and accurate results can be obtained. The calorific value test also helps in selecting fuel that suits the needs and requirements of the application, and plays a role in the design of efficient combustion systems [31]. Calculation of calorific value using Eq. (4).

$$CVs = \frac{\Delta t\ x\ w - (CV_T + CV_W)}{M} \quad (4)$$

Where; CVs is the heating value of the sample [cal/gr], Δt is the change in temperature [ºC], w is the heating value of water = 2602.18 [cal/ºC], CV_T is the heating value of thread 21 cal, CV_W is the heating value of wire 9.32 cal , and M is the sample mass = 1 gram.

Volatile matter

Volatile matter is an unstable material. Volatile matter tends not to stay in one state and will quickly move to another state, or evaporate, if the right conditions are met. The volatility of volatile substances is determined not by temperature but rather by the vapor pressure required to initiate a phase change. Calculation of evaporated substance levels using Eq. (5).

$$v_m = \frac{m_2 - m_3}{m_2 - m_1}\ x\ 100\% \quad (5)$$

Where; vm is the volatility of the substance [%], m1 is the weight of the container (the cup used), m^2 is the weight of the container + sample, m^3 is the weight of the container + sample (after coming from the oven).

4. RESULTS AND DISCUSSION

4.1 Briquette Test Results Data

Based on statistical data processing, the results of testing the quality of Rice Husk (RH) and Corn Cob (CC) charcoal briquettes were obtained. Table 2 shows the test results of the process for moisture content, ash content, combustion rate, heating value and volatile matter.

Table 2. Briquette quality testing data

Briquette Compt* (g)	Moisture content (%)	Ash content (%)	Burning rate (g/mnt)	Calorific value (cal/gr)	Volatille matters (%)
50 : 50	5	15	0.17	6553.19	10
40 : 60	15	30	0.20	5121.99	10
30 : 70	20	80	0.25	5017.91	30

Description: *rice husks: corn cobs

4.1 Moisture content Analysis

Figure 5 is a graph of testing moisture content values, where a moisture content of 15% occurs with a composition of 40 grams of rice husks and 60 grams of corn cobs.

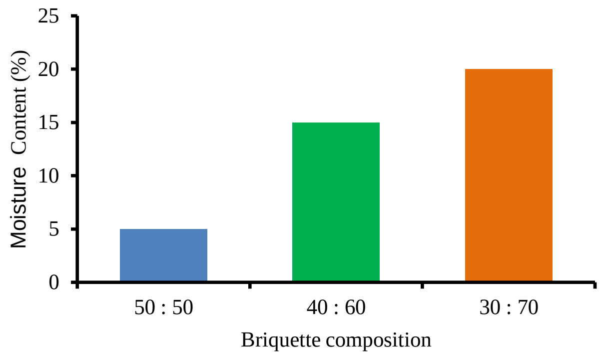

Figure 4. Moisture content test graph

Meanwhile, a higher moisture content value occurred at 20% with a mixture of 30 grams of rice husks and 70 grams of corn cobs. Based on the moisture content value, the best mixture is 5% with a mixture of 50 grams of rice husks and 50% grams of corn cobs.

So the more components in the composition of rice husks, the lower the moisture content value will be. The lowest value for results that meet standards (SNI) is 5% with a mixture of 50% rice husks and 50% corn cobs.

4.2 Ash Content Analysis

Ash is the residue or waste produced from a product, and one of the main components contained in ash is the mineral silica. The high ash content in briquettes can have a negative impact on the calorific value produced. In general, the higher the ash content in the briquettes, the lower the quality. The ash content in briquettes has an unfavorable impact on their quality, because high ash content can reduce the calorific value produced by the briquettes.

Thus, the lower the ash content in the briquettes, the better the quality. The ash content in biomass is residue from combustion which has flammable properties. Figure 5 shows the results of testing the ash content of corn husk and corn cob briquettes.

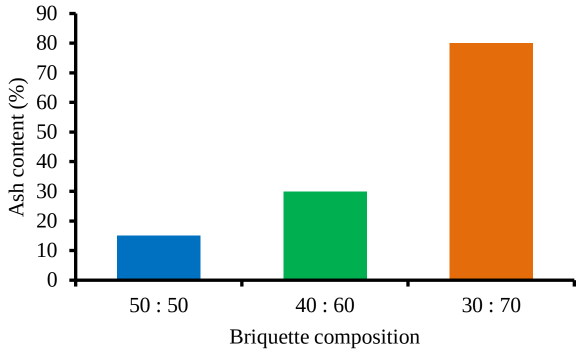

Figure 5. Ash content test graph

Figure 5 is a graph of testing ash content values. The results of the graph show that the ash content value with a composition of 50 grams of rice husks and 50 grams is 15%, while with a mixture of 40 grams of rice husks and 60 grams of corn cobs the ash content value is 30%. And the highest value was obtained with a mixture percentage of 30 grams of rice husks and 70 grams of corn cobs with a moisture content value of 80%. The high ash content in briquettes is caused by the carbonization process not being optimal.

4.3 Burn Rate Analysis

Particle size has an influence on the combustion rate. Smaller particles tend to burn faster. Apart from that, smaller particles can also produce higher temperatures compared to larger particles. The relationship between particle sizes, which are measured in mesh units. Figure 6 shows the results of the burning rate test.

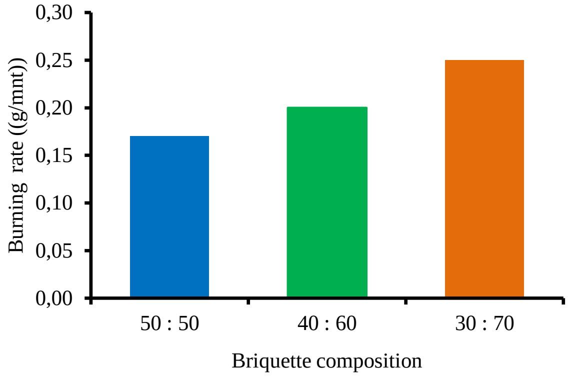

Figure 6. Burn rate test graph

Figure 6 shows that the results with a composition of 50 grams of husks and 50 grams of corn cobs produced a burning rate of 0.17 g/minute, while the mixture composition of husks at 40 grams and 60 grams of corn cobs increased by 0.2 g/minute. And the highest value was obtained with a composition percentage of 30 grams of rice husks and 70 grams of corn cobs at 0.25 g/minute.

4.4 Calorific Value Analysis

Calorific value has an important role in determining the quality of briquettes. The higher the heating value, the better the quality of the briquettes produced. Low moisture content, ash content and volatile matter can increase the heating value. High carbon content can also increase the calorific value.

The calorific value test aims to determine the extent to which briquettes can produce combustion heat. The results of testing the heating value with a Bomb Calorimeter are shown in Figure 7.

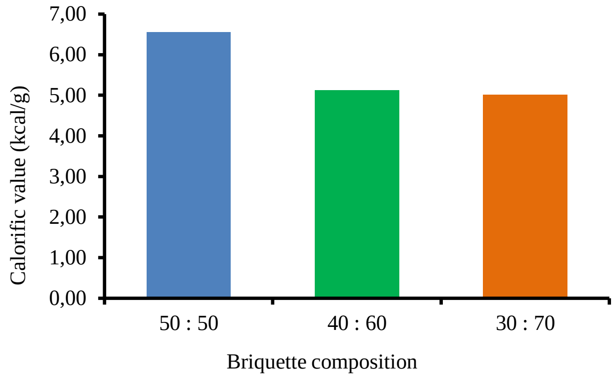

Figure 7. Calorific value test graph

Based on the graph (Figure 7), it appears that the results of the calorific value test, which produced a calorific value of 5.017 kcal/gram, occurred in the composition of 30 grams of rice husks and 70 grams of corn cobs, while the composition of 40:60 increased, namely 5.011 kcal/gram. to 5.121 kcal/gram. Meanwhile, the highest calorific value is 6.533 cal/gram, for the composition ratio of rice husks and corn cobs is 50: 50. This amount of energy can produce heat which can be used for small-scale industrial purposes.

4.5 Analysis of Substance Volatility

Volatile matter is a component in briquettes that can evaporate as a result of the decomposition of compounds that are still in it, except water, bound carbon and ash content [32]. The volatile content is also influenced by the amount of rice straw biomass used. A high volatile material content will affect the combustion rate and flame intensity. Figure 8 shows the results of testing for volatile matter from rice husk and corn cob briquettes.

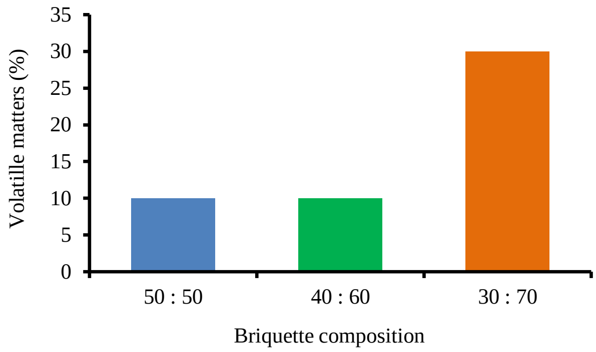

Figure 8. Volatile matter test graph

Figure 8 shows the lowest value with a mixture of 50 grams of rice husks and 50 grams of corn cobs with a volatility value of 10%. Meanwhile, the 40:60 composition produces the same volatility value, namely 10%. The highest volatility value occurs in the 30 : 70 composition at 30%.

As verification of the test result data, it is compared with the standard (SNI No. 01-6235-2000), in order to obtain recommendations for the best quality of the briquette mixture, namely using Table 3.

Table 3. The composition of wood charcoal briquettes is based on SNI standards* [

Test Type	Units	Value
Ash content	(%)	≤ 8
Loss on Drying (LOD)	(%)	≤ 15
Moisture content	(%)	≤ 8
Calorific value	(kal.g)	≥ 5000

*SNI No. 01-6234-2000

Based on table 3, the best composition for briquettes, a mixture of rice husks and corn cobs, is 50: 50 grams. Where the test results show that the moisture content is ≤ 8%, namely 5%; Calorific value ≥ 5000, namely 6553.19 cal/g and volatility of the substance (volatille matters) ≤ 15%, namely 10%. So, based on this study, it can be a recommendation for bio-people using rice husks and corn cobs as the best mixture of 1: 1. The mixture of rice husks and corn cobs has the potential as an alternative bio-energy briquette for household scale industrial purposes.

However, the weakness of this mixture of rice husks and corn cobs is the high ash content. The resulting ash content for the three composition variations in this study was above 8%, namely 15 – 80%. The ash content in biocharcoal briquettes mixed with rice husks and corn cobs tends to be high because both raw materials have relatively high mineral content. Rice husks and corn cobs contain minerals such as silica, potassium, calcium and magnesium which can increase the amount of ash in the biocharcoal briquettes produced.

The process of making biochar involves heating raw materials at high temperatures in an oxygen-limited environment. This process causes the decomposition of organic components in the raw material, leaving mineral residue or ash as a result. The high mineral content in rice husks and corn cobs will produce large amounts of ash after the combustion process.

High ash content in biocharcoal briquettes can have an impact on the quality and usability of the final product. Although ash can provide several benefits, such as increasing the porosity and structural stability of biochar, levels that are too high can reduce the calorific value and produce undesirable residues when biochar is used, especially in applications such as burning or fertilizing plants.

Therefore, in the process of making biocharcoal briquettes, it is important to consider the proportion of raw materials to optimize the quality of the final product by minimizing excessive ash content.

5. CONCLUSIONS

Briquettes from a mixture of rice husks and corn cobs still produce high ash content, which has an impact on calorific value, leaves residue and can cause environmental problems. However, the composition of a mixture of rice husks and corn cobs in a ratio of 50:50 or 1:1 is still feasible and has the potential to be developed into bioarang briquettes. Thus, development of technology or methods to reduce the ash content of this briquette mixture needs to be carried out in the future.

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7. AUTHOR CONTRIBUTIONS

- Conceptualization, data curation, formal analysis : Asrori, Mirza Fathus Syifa Alfarisyi
- Investigation: Mirza Fathus Syifa Alfarisyi
- Methodology: Asrori, Ach. Muhib zainuri
- Project administration: Mirza Fathus Syifa Alfarisyi
- Supervision: Asrori
- Validation: Eko Naryono
- Writing – original draft: Asrori, Mirza Fathus Syifa Alfarisyi
- Writing – review & editing: Asrori

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